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GB A 2128142	US 3608925
GB A 2039834	US 3194581
GB 1334971	US 2941815

(58) Field of search
B7D

(54) Vehicle suspension

(57) The present invention provides a vehicle suspension system 3 for adjusting the attitude of a vehicle 1 during cornering and having at least one variable level body support means 4 spaced laterally from the centre of gravity of the vehicle body 1. A steering wheel direction responsive control means 14 is formed and arranged for controlling the variable level support means 4 so as to tilt the vehicle body 1 laterally to that side to which the steering wheels 2 deviate from the straight-ahead direction in proportion to the degree of deviation.

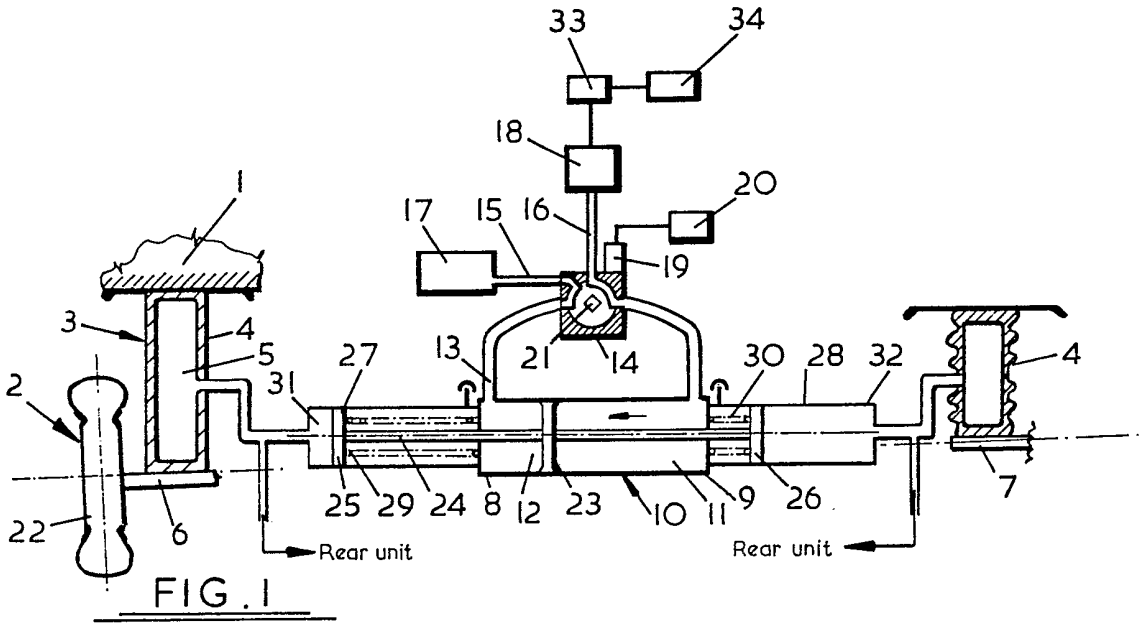

FIG. 1

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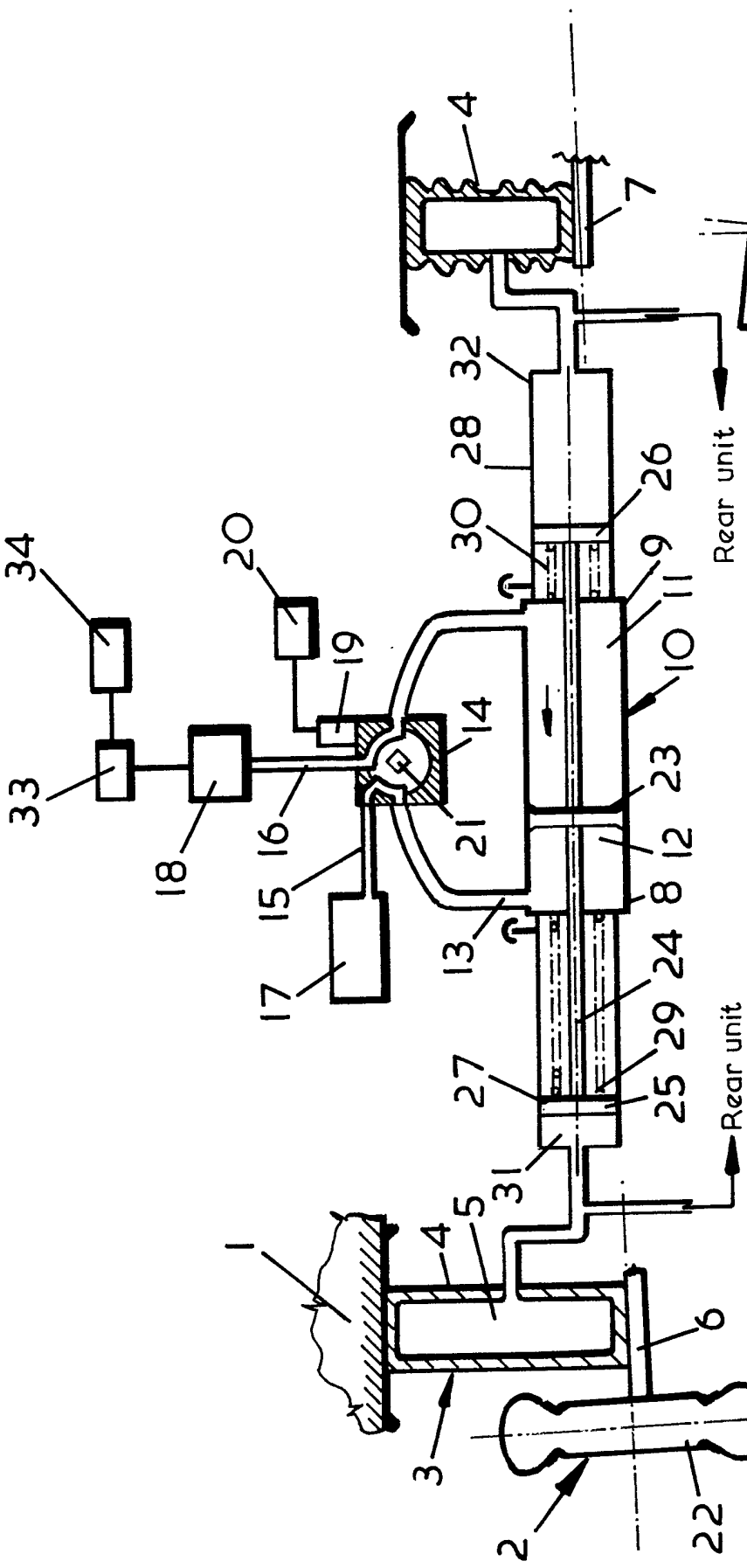

FIG. 1

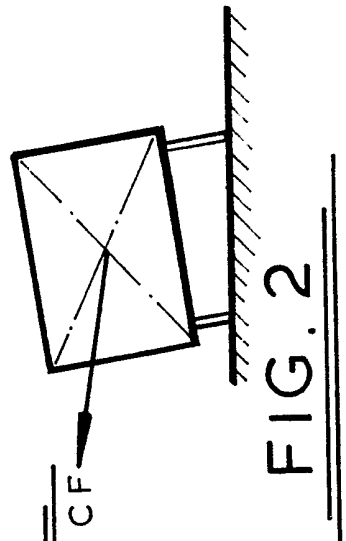

FIG. 2

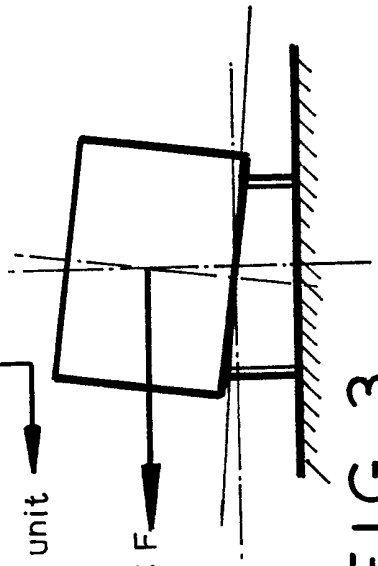

FIG. 3

SPECIFICATION

Vehicle suspension

This invention relates to a vehicle suspension system and in particular to a suspension system for adjusting the attitude of a vehicle during cornering.

During cornering a vehicle is subjected to centrifugal forces which are generally proportional to the radius of curvature of the vehicle path and hence deviation of the steering wheels from the straight ahead direction and the road speed of the vehicle, and which tend to tilt the vehicle body laterally to one side of its longitudinal axis in a direction radially outwards with respect to its arcuate pathway. This tilting can result in significant discomfort to the occupants of the vehicle and more seriously, tends to interfere with proper handling of the vehicle with respect to maximum traction, longitudinal stability etc.

It is an object of the present invention to avoid or minimize one or more of the above disadvantages.

The present invention provides a vehicle suspension system for adjusting the attitude of a vehicle during cornering and comprising at least one variable level body support means spaced laterally from the centre of gravity of the vehicle body, and steering wheel direction responsive control means formed and arranged for controlling said variable level support means so as to tilt the vehicle body laterally to that side to which the steering wheels deviate from the straight-ahead direction in proportion to the degree of deviation.

Most desirably the system also includes road speed responsive control means formed and arranged for controlling the variable level support means so as to control said tilting of the vehicle body laterally in proportion to the road speed of the vehicle also.

With a suspension system of the present invention the centrifugal forces which act on a vehicle during cornering so as to tend to tilt it laterally radially outwards are counter balanced to a greater or lesser extent thereby tending to maintain the normal attitude of the vehicle or even providing radially inward tilting. This in turn results in improved cornering and/or greater comfort of the occupants of the vehicle.

Further preferred features and advantages of the invention will appear from the following detailed description given by way of example of a preferred embodiment illustrated with reference to the accompanying drawings in which:

Figure 1 is a partially schematic diagram of a vehicle suspension system of the invention;

Figure 2 is a schematic end elevation of a car with a conventional suspension during cornering; and

Figure 3 is a corresponding view of a car with a suspension system according to Fig. 1 during cornering.

Fig. 1 shows schematically a vehicle body 1 mounted on road wheels 2 via a suspension system 3 according to the present invention. The suspension shown is basically of the hydraulic type in which the body 1 is mounted on longitudinally extensible chambers 4 containing pressurized hydraulic fluid 5.

The chambers 4 at opposite sides, 6,7 of the vehicle (generally 2 or more are provided at each side) are connected to respective ends 8, 9 of a double acting piston-and-cylinder means 10. In more detail the latter comprises a central chamber 11 containing control hydraulic fluid 12 and having connections 13 at or near each end to a 4-way control valve 14 which is also connected 15, 16 to a reservoir 17 and a pump means 18 (e.g. a centrifugal type pump).

The control valve 14 is provided with a valve drive means 19 connected to a steering wheel sensor means 20 formed and arranged for operating said drive means to displace the valve member 21 of the control valve from its neutral position to an operative position corresponding to and proportional to the deviation of the steering wheels 22 from the straight ahead position. In this operative position the valve member 21 connects the pump means 18 to that side 16 of the central chamber 11 to which the steering wheels deviate from the straight ahead position (in the radially inward side of the corner), the size of the valve metering opening being proportional to the magnitude of the deviation. At the same time the other (radially outward) side 15 of the central chamber 11 is connected to the control hydraulic fluid reservoir 17. Thus pressurized control fluid is supplied to the radially inward side (high-pressure side) of the piston 23 in the central chamber 11 and fluid relieved from the radially outward side (low-pressure side) thereby displacing the piston 23 to the radially outward side.

At each side the piston 11 has an elongate piston rod 24 through which it is connected to a respective outer piston 25, 26 housed in a respective outer chamber 27, 28, a respective spring 29, 30 being provided between the central chamber 11 and each said outer piston 25, 26. Each said outer chamber 27, 28 is connected at its outer end 31, 32 to the extensible chambers 4 at that side of the vehicle. Thus, as may be seen in Fig. 1, when the vehicle is negotiating a right hand corner with the steering wheels turned towards the right, the piston 23 in the central chamber 11 is displaced to the left thereby in turn displacing the outer cylinders to the left and expelling hydraulic fluid 5 from the left hand one while drawing in fluid to the right had one. As a result the left hand extensible chamber is longitudinally extended raising the vehicle body at that side whilst the other contracts and lowers the vehicle body on the other side.

The degree of tilting of the vehicle body resulting from the above is further modulated by providing the hydraulic pump 18 with control means 33 arranged to control the rate of pumping in proportion to the output of a roadspeed sensor means connected thereto and which is conveniently in the form of a final drive speed sensor 34 formed and arranged to monitor the speed of the propellor shaft or other final drive means of the vehicle

transmission.

As the vehicle returns to the straight ahead direction the valve member of the control valve returns to its neutral position with both ends of the central chamber connected to the reservoir and/or to each other so that both ends become equally pressurized and the double acting central chamber piston 23 can be returned to its central neutral position by the springs 29, 30 acting on the outer pistons 25, 26, thereby allowing the expansible chambers 4 also to return to their neautral positions. This in turn restores the vehicle body to its level attitude or trim (with respect to a transverse axis of the vehicle).

It will be appreciated that various modifications can be made without departing from the scope of the present invention. Thus for example instead of a central unified directly linked control of the expansible chambers on opposite sides of the vehicle, there could be used separate hydraulic systems connected to common cornering radius and road speed sensor means or even separate ones. In this case it will of course be necessary to provide additional control means for correlating the expansion or contraction of the respective side expansible chambers with the direction of steering. Also other types of suspension e.g. coiled spring type may be used with the present invention by incorporating hydraulic ram units within the basic coil spring suspension system.

In addition to the abovementioned advantages the present invention also provides further consequential advantages including increased fuel economy and reduced brake wear through the reduced need for braking at corners due to the higher cornering speeds made possible. In addition the loading differential between the wheels at opposite sides of the car may be reduced as may also the maximum stresses on the basic vehicle suspension. Although naturally some power will be required in pressurising the fluid operating system and/or driving the double-acting piston, this will be compensated by the reduction in energy lost during braking.

CLAIMS

1. A vehicle suspension system for adjusting the attitude of a vehicle during cornering and comprising at least one variable level body support means spaced laterally from the centre of gravity of the vehicle body, in use of said system, and steering wheel direction responsive control means formed and arranged for controlling said variable level support means, in use of said system, so as to tilt the vehicle body laterally to that side to which the steering wheels deviate from the straight-ahead direction in proportion to the degree of deviation.

2. A suspension system as claimed in claim 1 wherein are provided at least two laterally spaced apart variable level body support means disposable at either side of said vehicle.

3. A suspension system as claimed in claim 2 wherein is provided a said variable level body support means formed and arranged so as to be disposable between a respective one of each of the wheels of said vehicle in use of the system.

4. A suspension system as claimed in any one of claims 1 to 3 which includes road speed responsive control means formed and arranged for controlling the variable level support means so as to control the lifting of the vehicle body laterally in proportion to the road speed of the vehicle in use of the system.

5. A suspension system as claimed in any one of claims 1 to 4 wherein the variable level support means comprises pressurized fluid operated longitudinally extensible support means.

6. A suspension system as claimed in claim 5 wherein said support means comprise expansible chambers.

7. A suspension system as claimed in claim 5 wherein said support means comprise piston and cylinder means.

8. A suspension system as claimed in any one of claims 5 to 7 wherein said variable level support means includes a pressurized fluid source, a double acting piston and cylinder means having opposite sides connected to said variable level support means at opposite sides of the vehicle, in use of the system, and valve means for selectively connecting the pressurized fluid source to the double acting cylinder at either side of the double acting piston as required.

9. A suspension system as claimed in claim 8 wherein said valve means is formed and arranged for variable rate metering of the pressurized fluid, in use of the system, in proportion to the control means output.

10. A suspension system as claimed in claim 8 or claim 9 wherein said pressurized fluid source includes a variable rate fluid drive means for supplying fluid pressurized in proportion to the control means output.

11. A suspension system as claimed in claim 10 wherein said fluid drive means is drivingly connected, directly or indirectly, to the final drive to the vehicle wheels, whereby the fluid is pressurized in proportion to the rotational speed of the vehicle wheels and thereby the speed of the vehicle.

12. A suspension system as claimed in any one of claims 8 to 11 wherein said double acting piston is provided with resilient biasing means formed and arranged for biasing said piston towards its neutral position.

13. A suspension system as claimed in any one of claims 5 to 12 wherein the pressurized fluid is pressurized hydraulic fluid.

14. A vehicle suspension system substantially as described hereinbefore with particular reference to the accompanying drawings.

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